LOGANEnergy Corp.

Initial Report…FY'02 CERL PEM Demonstration Program
Robins Air Force Base PEM Project
Fire Station # 1, Robins AFB, GA
May 5, 2003

Contents

Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the fuel cell power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small scale fuel cell generators will soon be ready to tackle thousands of residential and small scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, assisted by a significant DOD investment, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner highly efficient fuel cell/hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide thermal Btus for heating and cooling loads-demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of thermal Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers, Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy through its FY'02 PEM Demonstration Program to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three seemingly incongruous events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small scale fuel cell at Robins AFB, GA. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,
2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,
3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,
4. Measuring the cost of operating a PEM unit under real market conditions,
5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.
6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by the Robins AFB Advanced Power Technology Office, Plug Power and Energy Signature Associates.

Robins AFB, GA PEM Site Selection and Installation

In February 2002 Sam Logan of LOGANEnergy met with Mr. Carl Perazzola and Mr. John Williams at Robins AFB to advance the possibility of hosting a CERL FY'02 PEM demonstration unit at a site on the base. Since Mr. Perazzola is the director of the Advance Power Technology Office at Robins and currently collaborating with CERL in other fuel cell projects, he decided immediately that Robins should host a demonstration unit. In June of 2002 LOGAN submitted Robins AFB to CERL as a candidate site for the FY'02 PEM Program. In September 2002, Robins sent 8 officers and enlisted men to the PEM Seminar LOGAN conducted at the Renaissance Hotel in Atlanta; noting a great deal of enthusiasm for the DOD PEM program. In December 2002, CERL notified LOGAN that Robins was selected to host a demonstration unit. In February 2003, Robins AFB hosted a project kick-off meeting that was attended by representatives of CERL, LOGAN and the Advance Power Technology Office. After visiting several possible sites, the group consensus favored selecting the Robins AFB Fire Station. In mid March 2003, Plug Power shipped GenSys SN#192 fuel cell to Robins. On April 23, 2003, LOGAN started the unit for the first time.

Figure 1

Figures 1 and 2, above and at right are photos of the fuel cell on its pad at the entrance to the Robins AFB Fire Station, which is centrally located in the Robins community, and where the installation, itself, is very visible to passers-by. The station facility manages and dispatches respondents to fire and other base emergencies. The facility houses a full kitchen and dorm rooms for the emergency crews. The fuel cell was rigged onto the pad, at right, with the assistance of a base fork truck. The mechanical room is conveniently located behind the adjacent brick wall to the right of the fuel cell.

Figure 2

Figure 3 below is a photo of the unit on its pad showing the electrical interface on the building wall at right. The doorway to the mechanical room can also be seen on the right side of the photo.


Figure 3


Figure 4

Figure 4 at right shows the fuel cell interconnect with natural gas service. The photo clearly shows the gas meter and regulator. It also shows the thermal recovery fluid supply and return lines running between the fuel cell and the thermal storage tank located within the adjacent mechanical room seen in Figure 5 below

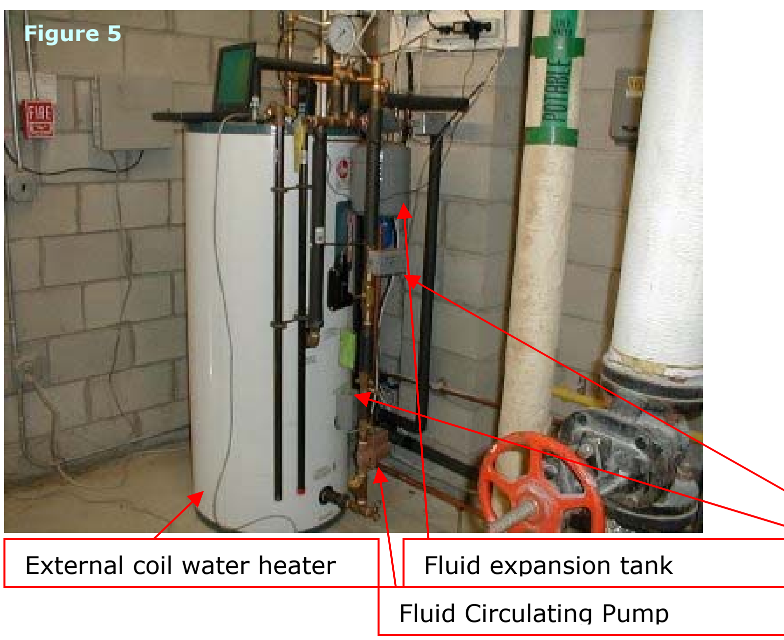


Figure 5

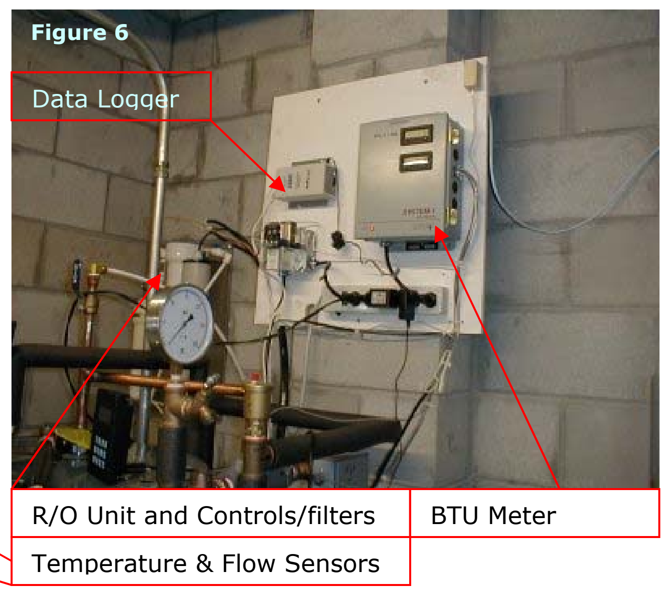


Figure 6

Figures 5 and 6 above illustrate the mechanical interface with the facility's domestic hot water supply. The new tank in Figure 5 draws waste heat by circulating a glycol/water solution through the fuel cell heat exchanger. The new heater acts as a preheat source for the existing natural gas fired hot water heater also located in the mechanical room.

Installation Line Diagram

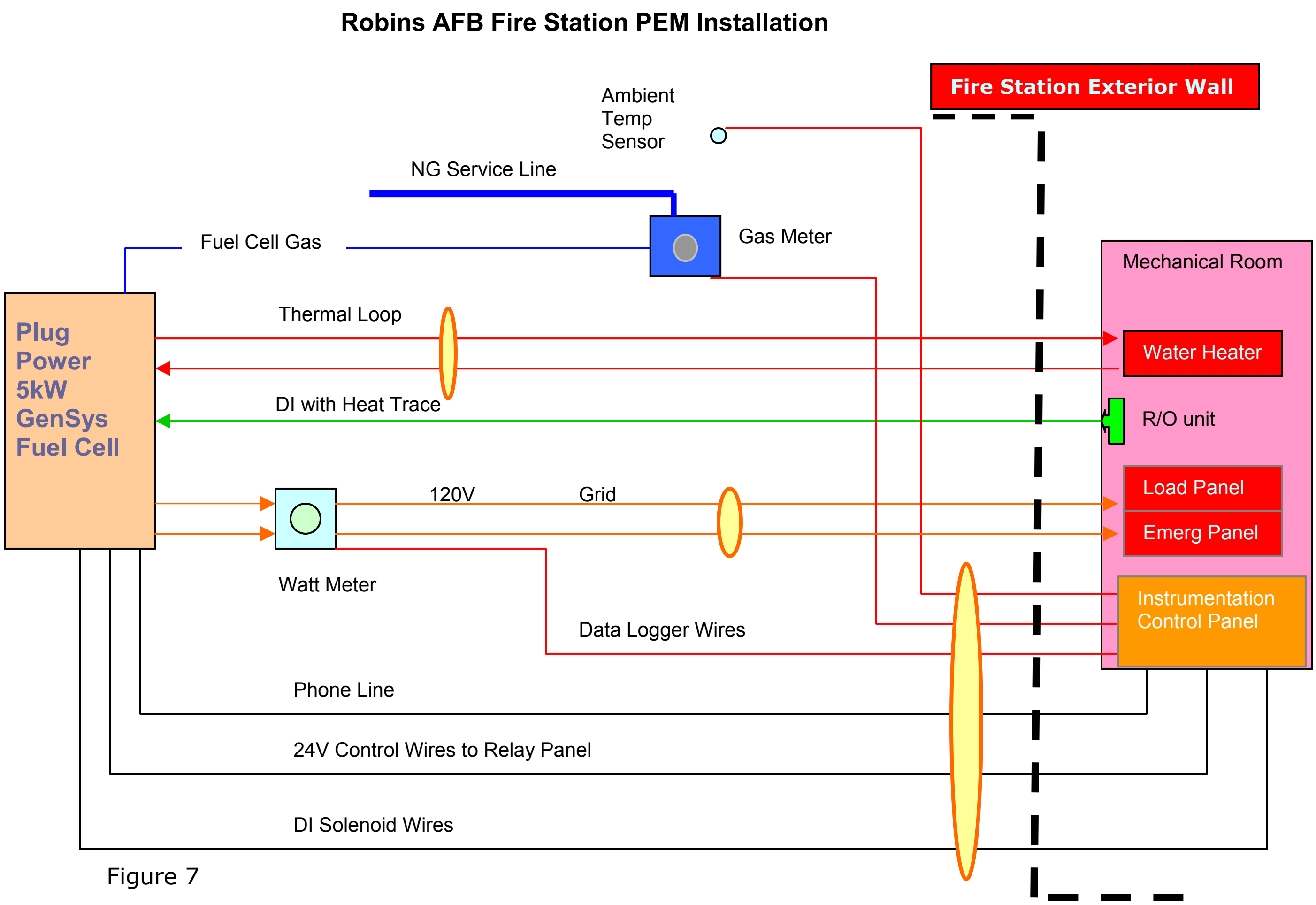
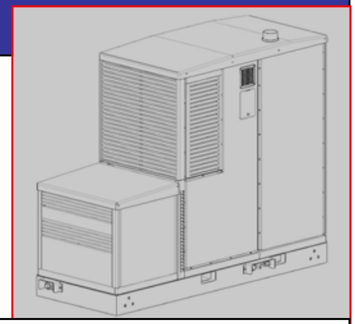


Figure 7

GenSys5C Product Specifications

Plug Power Fuel Cell System



The GenSys5C is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, the 5C is a clean and efficient source of power.

Specifications

Physical	Size (L X W X H):	84 1/2" X 32" X 681/4"
Performance	Power rating:	5kW continuous
	Power set points:	2.5kW, 4kW, 5kW
	Voltage:	120/240 VAC @ 60Hz
	Power Quality:	IEEE 519
	Emissions:	NO_X < 5ppm
		SO_X < 1ppm
		Noise < 70 dBa @ 1meter
Operating Conditions	Temperature:	0°F to 104°F
	Elevation:	0 to 750 feet
	Installation:	Outdoor/CHP
	Electrical Connection:	GC/GI
	Fuel:	Natural Gas
Certifications	Power Generation:	CSA International
	Power Conditioning:	UL
	Electromagnetic Compliance:	FCC Class B

Dimensions

Length .... 84 inches
Width .... 32 inches
Height .... 68 ¼ inches

Operating Requirements

Fuel Type .... Natural Gas
Temperature .... 0 degrees F to 104 degrees F

Outputs

Power Output 5kW
Voltage .... 120/240 VAC @ 60Hz
Noise .... < 70 dBA@ 1 meter

Certifications

CSA International .... Fuel Cell System
UL .... Power Conditioning Module

Figure 8

Installation Application

Figure 7, above, describes a one line diagram of the Robins Fire Station fuel cell installation. The diagram illustrates utility and control interfaces including, gas, power, water and instrumentation devices installed in the adjacent mechanical room of the fire station. Figure 8, above, lists the specifications of the Plug Power GenSys5C PEM technology demonstration fuel cell chosen for this site.

The electrical conduit runs between the facility load panels and the fuel cell are approximately 25 feet. The Reverse Osmosis/DI water tubing run that provides filtered process water to the power plant is approximately 15 feet distance, and the thermal recovery piping runs between the fuel cell and the hot water heater are also approximately 15; both may also be seen Figures 4 and 5 above. The new water heater is a 74 gallon Rheem external heat coil unit that preheats and stores hot water for domestic consumption. Fuel Cell waste heat should be adequate to meet the domestic hot water demand of the facility. Figure 6 indicates the location of an Onicon BTU meter on the thermal recovery system that will record the waste heat utilization by the facility. Data logging will be accomplished with an Ultralite Logger also indicated in Figure 6 above.

The fuel cell inverter has a power output of 110/120 VAC at 60 Hz, matching the building distribution panel in the mechanical room with its connected loads at 110/120 VAC. The installation includes both a grid parallel and a grid independent configuration as indicated in Figure 4. The unit provides stand-by power to a new 100amp critical circuit panel that serves several kitchen appliances and other plug loads. A two-pole wattmeter monitors both the grid parallel and grid independent conductors to record fuel cell power distribution to both the existing panel and the new critical load panel.

LOGAN tied the fuel cell gas piping into the existing service line adjacent to the fuel cell pad, and installed a gas meter to calculate fuel cell usage as indicated in Figure 4 above. A regulator at the fuel cell gas inlet maintains the correct operating pressure at 14 inches water column.

A phone line connection with the fuel cell modem provides communications with Plug Power and LOGAN customer support functions.

The installation proceeded according to plan with minimal inconvenience to the base or the host site.

Permitting

LOGAN worked closely with the Robins Civil Engineering Environmental Department to insure the installation satisfied all environmental requirements. No permits were required or issued for this site.

Start-up and Commissioning

The first start occurred on April 25, 2003. Prior to starting the unit the items covered in Figure 6, below, were completed. LOGAN's fuel cell systems technician will continue to test and monitor the unit in accordance with the factory recommended procedures to insure completion of the items listed in Figure 7, below. Operations testing and tuning of the fuel cell's electrical and mechanical systems will continue to insure smooth and reliable performance. It is anticipated that the unit will be declared operational by June 2, 2003.

Service incidents and facility calls will be reported on the sample Service Call Report form listed below as Figure 8.

An Economic Analysis of the Robins AFB project appears in Figure 9 below.

Installation Check List

TASK	SIGN	DATE	TIME(hrs)
Batteries Installed			
Stack Installed			
Stack Coolant Installed			
Air Purged from Stack Coolant			
Radiator Coolant Installed			
Air Purged from Radiator Coolant			
J3 Cable Installed			
J3 Cable Wiring Tested			
Inverter Power Cable Installed			
Inverter Power Polarity Correct			
RS 232 /Modem Cable Installed			
DI Solenoid Cable Installed with Diode			
Natural Gas Pipe Installed			
DI Water / Heat Trace Installed			
Drain Tubing Installed			

Figure 6

Commissioning Check List

TASK	SIGN	DATE	TIME (hrs)
Controls Powered Up and Communication OK			
SARC Name Correct			
Start-Up Initiated			
Coolant Leak Checked			
Flammable Gas Leak Checked			
Data Logging to Central Computer			
System Run for 8 Hours with No Failures			

Figure 7

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SERVICE CALL REPORT **SYSTEM INFORMATION**

System Serial #: ______________________________ Date _______

Purpose of Service Call: ☐Repair ☐Maintenance ☐ECN (Check all that apply)

Date Time

Date/Time shutdown ___________ ___________

MAINTENANCE / REPAIR INFORMATION

Service Tech Name: ______________________________

Travel Man-hours: _____________

Troubleshooting Manhrs: _____________

Repair Man-hours: _____________

Spare Part Delay Time: _____________

*Work Performed:*____

____

*Technician Comments:*____

____

____

FAILURE REPORT SUMMARY

Date	Description of Problem	Rpt #	Initials

Figure 8

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FY' 02 RESSDEM
Rrobins AFB PEM Fuel Cell Economic Analysis

Estimated Project Utility Rates	
1) Water (per 1,000 gallons)	$1.69
2) Electricity (per KWH)	$0.0651
3) Natural gas (per MCF)	$5.25

Estimated First Cost	
Plug Power 5 kW SU-1	*$65,000*
Shipping	*$1,800*
Installation electrical	*$1,250*
Installation mechanical	*$3,200*
Watt Meter, Instrumentation	*$3,150*
Site Prep, labor materials	*$925*
Technical Supervision	*$8,500*
Total	***$83,825***

Assume Five Year Simple Payback	**$16,765**

Forcast Operating Expenses	**Volume**	**$/Hr**	**$/ Yr**
Natural Gas			
Mcf/hr @ 2.5kW	*0.032838*	*$0.17*	*$1,359*
Water			
Gals/Yr	*4918*		*$8.31*

Add Total Annual Operating Costs	**$1,368**
Total Annual Costs (Ammortization + Expenses)	**$18,133**

Economic Summary		
Forcast Annual kWH	*19710*	
Annual Cost of Operating Power Plant	*$0.0694*	kWH
Credit Annual Thermal Recovery	*-0.016489*	kWH
Project Net Operating Cost	*$0.0529*	kWH
Ammount Available for Financing	*$0.0122*	kWH
Add 5 Yr Ammortization Cost / kWH	*$0.8506*	kWH

Current Demo Program Cost Assuming 5 Yr Simple Payback	**$0.9200**	**kWH**

***NOTE**Does not include allowance for cell stack life cycle costs or service over 5 year economic senario*

Figure 9

Project Contacts

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5. Plug Power: Scott Wilshire
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   Scott_Wilshire@plugpower.com

Figure 10

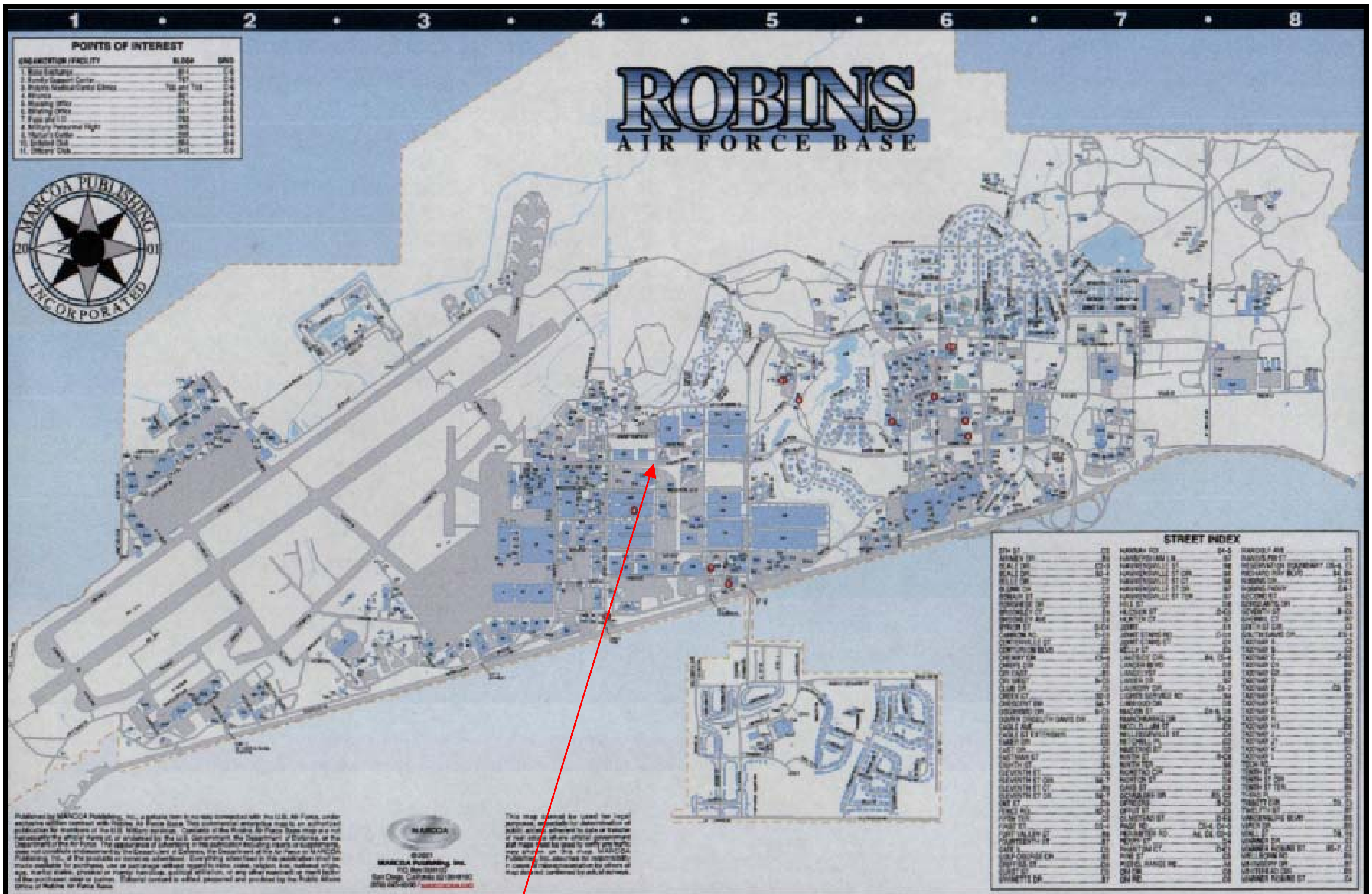

Figure 13